WOODIGITAL

01.1

Desk Research:

The “Woodworker 4.0”. Market needs, knowledges, skills and competences required in the context of the *Twin Transition* (Green and Digital) of the furniture sector

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Content

Introduction

The wood-furniture sector is facing a phase of "Green and Digital" Twin Transition[1] at European level, imposed on the one hand by the ongoing environmental and climatic emergency, on the other encouraged by the development of new technologies, tools and methodologies accessible and applicable by SME's, which characterize the sector.

The impact of this transition looks more like a new revolution than a normal evolution: the impact on fields like design, product manufacturing, business processes, work organization and market relations will radically transform the sector, with a speed and radicalism never experienced before.

New challenges, for new opportunities.

The business world, the VET and HE sector-related educational institutions, the research world and the institutional stakeholders are all aware that this transition is essential for the wood-furniture sector to remain competitive, while preserving its heritage of creativity and know-how. The tools increasingly adopted by Policy Makers at European and national level to support both innovation (for example funds for the development of Industry 4.0, eco-sustainable materials and processes, Circular Economy) and sustainability of the production system, business direct investments in product and production processes innovation, the contribution of research to develop sustainable and adequate solutions for large-scale production lose effectiveness without the contribution of a training chain dedicated to new workers and employees in the sector.

Can the wood-furniture sector be as attractive to young Europeans as other sectors such as food, fashion, automotive? Digitalization and sustainable development linked to the circular economy can also be a driver to facilitate interest in the sector by young Europeans, digital natives and with a strong environmental sensitivity.

Adequate and innovative training, capable of exploiting the potential of new technologies, therefore responds to a double market demand: to train young people capable of facing innovation and attract talented young people who can bring their talent and passion into the wood-furniture sector.

[1] SAWYER Project – Social Dialogue EU Programme – Final Report *Impacts of the twin transition on the EU furniture industry*

1. Trends and possible scenarios for the wood-furniture sector

In 2019[2], the EQWOOD project provided a comprehensive overview of the opportunities and threats for the wood-furniture sector at European level by interviewing over 115 stakeholders from the world of business, research, training and institutions from Spain, Belgium, Italy, France, Hungary and Bulgaria.

Conclusions converge on some key points:

Main challenges / Threats

- *Competition from low cost / low labour market countries*
- *Ageing workforce*
- *Difficulties to attract young "Talents"*
- *Market Barriers*
- *Crisis (including Pandemic crisis)*

The European furniture sector faces enormous competition from countries having low production costs, in the low-and mid-range price segments, where the EU share in world furniture trade has significantly dropped in the last decade. China's EU market penetration is growing rapidly, and it is now the largest furniture exporter to the EU, supplying more than half of total furniture imports to the EU. The reliance on innovation and design as a competitive advantage of the European furniture sector, combined with an increase in global trade and digitalisation, makes it more vulnerable to weak protection and enforcement of intellectual property rights on the global markets.

The European furniture sector is also affected by some structural problems. The ageing workforce combined with difficulties to attract young workers may lead to disruptions in maintaining a skilled workforce and continuity of traditions and craftsmanship. Furthermore, boosting research and innovation requires sufficient finance, which is often inaccessible to SMEs.

While the EU is the most open global market, protectionist measures exist on other international markets, creating inevitable market distortions. EU furniture producers face both duties on imported materials and semi-finished products used in furniture, and tariffs on their exports of finished furniture products, thus decreasing the sector's global competitiveness. Moreover, their operational costs are increased by

[2] EQWOOD_ Quality Qualifications for the European Woodworking and Furniture Industry- Project – Erasmus + EU programme - Deliverable WP4 "Sectoral Information Report" – www.eqwood.org

environmental, sustainability and technical standards and regulations. All these factors, combined with the fact that the furniture sector has been severely affected by the recent crises – including the Covid-19 pandemic during the most part of 2020 and these first months of 2021 - have led to a significant drop in the number of companies, jobs and turnover, from which the sector is still trying to recover.

Opportunities

- *Export-oriented sector*
- *New customers from emerging countries*
- *New lifestyles trend*
- *High-end products*
- *Circular economy and new materials*
- *Digitization and key enabling technologies*
- *Synergies with tourism / cruising / hospitality / marine industry*

In recent years, the EU furniture sector has undergone significant changes – restructuring, technological advances and business model innovations, allowing it to be more export-oriented, and to focus on upgrading quality, design and innovation. Continuing investment in skills, design, creativity, research, innovation and new technologies can result in new products which are in line with the new demographic and lifestyles trends, as well as with new business models and supplier-consumer relationships. Moreover, research in advanced manufacturing technologies can result in the creation of high technology and knowledge intensive jobs, which would give the sector the attractiveness it needs towards the new generations. This could help to attract young students and job seekers to the sector, while keeping it highly competitive on the world stage.

European furniture manufacturers being recognised worldwide for their quality and design also create opportunities for the sector to further penetrate other markets, in particular in the high-end segments and emerging markets. The synergies with construction and tourism (involving the sectors like hotellerie / hospitality / cruising and marine industry), could also be exploited. The European furniture manufacturers set the trends at the global level, which is reflected by the fact that 12% of designs registered in the Office for Harmonization in the Internal Market relate to the furniture sector.

Otherwise, the opportunities driven by the Circular Economy and the new materials from sustainable sources used in the furniture production could have a positive impact on sales among environmentally concerned end-users within and outside the EU.

All in all, Europe maintains an important role in the furniture industry, although major structural changes in the world furniture sector, including the emergence and fast development of extra-European suppliers over the last 20 years have severely affected

the area, the production value is nearly EUR 88 billion, accounting for around a quarter of the world's furniture industry, which is half the Asian share. Western Europe provides the largest share, but Eastern countries are the fastest growing. Germany, Italy, Poland and the United Kingdom rank among the top 10 furniture manufacturers worldwide and hold a combined share of 14% of world production and almost 60% of European production.

1.1 Post Covid-19 pandemic scenarios

- *New consumer trend: "Home sweet Home"*
- *Digitization of processes management and customer relationship management*
- *Remote working*
- *Increasing costs of raw materials*

The crisis due to the Covid-19 Pandemic, if on the one hand implies a reduction in demand for the wood-furniture sector and downward global consumption scenarios (also following the limitation of tourist flows, with a consequent serious impact on the hospitality at a global level), on the other it could represent a "boost" for the "Twin Transition", whose effects should be taken into account for the development of medium-term training courses.

The first and clearest consequence of the pandemic crisis is a new attention and sensitivity by consumers towards their home[3]: forced to live there for a long time, they are willing to invest to improve it, with technological solutions also suitable for remote working, modular furniture to transform the home environment in flexible locations also for work or study, open spaces equipped with multifunctional furniture. This impacts on the furniture system not only from an economic point of view: it is necessary to develop furniture solutions that can adapt to home technological devices, with multifunction, durability and wear resistance characteristics suitable for intensive use.

The second consequence is the remotization of non-productive activities, with the consequent development of all the technologies that allow remote collaborative work (cloud Technologies, sharing platforms, e-learning tools, collaboration tools). The transition from "remote working" to "smart working" is a challenge that impacts the business organization of all mature sectors, including wood-furniture.

[3] See the Italian report on the Real Estate - *Scenari immobiliari-Report ISI*, 2020. www.scenari-immobiliari.it

Another aspect concerns the customer remote management. In addition to the above-mentioned technologies, we are witnessing a progressive spread of advanced CRM tools, as well as the development of new technologies for the remote presentation of products, catalogs and solutions. The first virtual fairs held in 2020 (fashion was a pioneer among the manufacturing sectors) are experiments where the integration of virtual reality / augmented reality, software for product customization and "dialogue room" are integrated to recreate an enveloping and meaningful experience for the customer. The matching platforms for producers and buyers / developers are becoming sophisticated digital spaces where the product presentation is often combined with its customization and personalization.

Equally noteworthy, although still in an embryonic state, are the production process remotization[4] examples coming from some manufacturing sectors. During the lockdown period, many companies had to remotely monitor production to adapt production flows to the needs of the moment, often subject to Covid-19 trend, thus achieving agile production. Others have initiated remote testing and management mechanisms of the systems, with the same degree of safety but with a significant decrease in costs compared to on-site procedures, to make it permanent even at the end of the emergency. Others have experimented with the 'rental' of production plants, which makes it possible to outsource production and modulate it according to needs, paying for the use of machinery: as in the case of Rolls Royce engines for airplanes, which are 'leased' by companies and paid per the hour of use with a pay per use model.

Added to this are the opportunities linked to product "Digital Twin" capable, on one hand, of representing the product, allowing navigation within it as well as a certain interaction with its components; on the other hand, during its life cycle, it must even be able to change and behave in accordance with what happens to the counterpart in the real world. Through technologies derived from the gaming world, the product and processes are integrated into multiple scenarios, which simulate complex situations, subject to the variables of time and space.

Last but not least, the revision of the entire supply chain. Following the COVID-19 pandemic, a strong increase in the price of raw materials available on the market emerges due to the intermittent lockdowns that, in the central months of 2020, significantly reduced their production and the possibility of exporting to European countries by especially Asian countries. This increase in cost requires alternative supply strategies and could strengthen the development of second raw material, obtained

[4] Marco Taisch – Politecnico di Milano – "Chi ha detto che è impossibile il lavoro da remoto?" https://www.paroledimanagement.it/chi-dice-che-non-si-puo-fare-smart-working-in-fabbrica/

from the recycling of post-consumer materials and the revision of a resilient, shorter and more local supply chain.

An example on which Belgium and Italy have been working for some time is the recovery of post-consumer mattresses made from expensive raw materials, they are currently difficult to disassemble and dispose of, with a strong environmental impact. The studies in progress move along different lines:

- How to produce a mattress using raw materials that guarantee performance and comfort, with lower costs - including energy - in the production phase?
- How to produce a mattress that is easily disassembled, to recover the materials at the end of their life and re-enter them in the production chain?
- Which sectors could use the materials recovered from post-consumer mattresses?
- What business models can be opened starting from the logistics for the recovery of post-consumer mattresses, to the eco-design of the same or other products starting from the recycling of the mattresses?

This is just an example -among the many available – of how circular economy opens up new spaces for research and development and new business opportunities.

2. Green and Digital: the "TWIN Transition"

1) *New technologies: Production, Processes, Protection*
2) *Circular economy transition: ReSOLVE Framework*
3) *New skills towards new consumer trends*

The evolution of the furniture sector shares two drivers with the entire European manufacturing sector:

- Digitization and the challenges associated with the use of new technologies.
- Sustainability (environmental, but also social and economic according to the SDG criteria established by the UN), with the development of new models of Circular Economy.

Two projects, resulting from the Social Dialogue[5] work for the furniture sector, have taken stock of both dimensions, measuring their impact on the professions that characterize the sector.

2.1 Digital Transition. DIGIT-FUR – The impact of digitization on the wood and furniture sector

The project DIGIT-FUR[6] has provided a better understanding of the possible scenario of the furniture sector due to digitization impact in 2025 and it forecasted which will be the effects of this transformation on 11 ESCO occupational profiles (ESCO – European classification of Skills/Competences, qualifications and Occupations) in relation to the changes in their tasks, occupational health and safety (OHS) risks and the related new skills, knowledge and competencies (VET) needed.

[5] European social dialogue refers to discussions, consultations, negotiations and joint actions involving organisations representing the two sides of industry (employers and workers). https://ec.europa.eu/social
[6] Support for Social Dialogue VP/2016/001. Grant Agreement Reference VS/2017/0027. www.digit-fur.eu

Before delving into the impact of digitization on professions, DIGIT-FUR offers some considerations that help focus on the needs and requirements of businesses.

The project has interviewed 56 European experts in the wood-furniture sector from various fields (research and development, companies, training, institutions) that identified a ranking of 108 factors that will impact the sector by 2025.

The results were subsequently validated through an in-depth workshop, which made it possible to identify the 30 with the greatest impact, shown in the table below[7]:

Rank	Factors	Importance Prob.x Imp. Max: 1.000	Probability Mean Value. Max: 100	Probability Standard Deviation	Impact Mean Value. Max: 10	Impact Standard Deviation
1	Big Data and the Internet of Things	720	88	15	8,20	0,92
2	Secure and Resilient ICT Infrastructure	692	91	11	7,60	2,37
3	Data Visualisation	662	87	14	7,60	2,17
4	Data Process for Knowledge Acquisition	614	84	19	7,30	2,21
5	Upgraded ICT Networks	596	84	15	7,10	2,47
6	Customer-Oriented Design	586	78	21	7,49	1,88
7	Sustainable Knowledge Infrastructure	583	83	13	7,05	2,01
8	Competition for Skills and Talent	576	76	20	7,60	1,93
9	Upgraded, Integrated Infrastructure Networks	575	80	13	7,20	1,81
10	Personalisation	551	78	16	7,07	2,18
11	Mass Customisation	548	76	18	7,17	2,04
12	Advanced Robotics	548	77	21	7,13	2,02
13	Consumer Innovation	547	76	13	7,20	1,62
14	Smart Logistic Tools	547	76	22	7,23	2,14
15	Sustainable Manufacturing	532	77	18	6,87	1,96
16	Agile Manufacturing	530	74	19	7,13	1,76
17	Niche Industries	523	79	19	6,63	2,31
18	Virtual Enterprise Environments	513	70	21	7,31	1,59
19	Eco-Industry Services	511	74	19	6,92	2,13
20	Developing Talents	508	72	20	7,10	2,18
21	Additive Manufacturing	495	75	21	6,62	2,04
22	Complex Value Chain	495	74	12	6,70	1,61
24	Open Innovation	492	72	13	6,80	1,48
25	Social Manufacturing	490	71	21	6,89	2,19
29	Intel. and Intermodal Transport Infrastructure	473	72	28	6,60	2,76
30	Circulation of Materials and Parts	472	71	23	6,68	2,03
31	Waste Minimisation	471	71	21	6,58	2,05
32	Personalised Production Lines	470	71	20	6,57	2,17

Factor in the 1st Quadrant: Probability > 69 & IMPACT > 6,5

Figure 1. Ranking of the Top 32 factors with an impact on the wood-furniture sector according DIGIT-FUR survey

[7] See *DIGIT-FUR Impacts of the digital transformation in the wood and furniture industry* – page 13

The factors can be grouped into three broad macro-categories:

A) New technologies
B) Reorganization of business processes aimed at greater sustainability / effectiveness
C) Re-design of products in line with new market trends

NEW TECHNOLOGIES	PROCESSES INNOVATION	PRODUCT INNOVATION
Big Data and the Internet of Things	Data Process for Knowledge Acquisition	Customer-Oriented Design
Secure and resilient ICT infrastructure	Upgrade ICT Networks	Personalisation
Data Visualisation	Sustainable Knowledge Infrastructure	Mass Customisation
Advanced Robotics	Competition for Skills and Talets	Consumer Innovation
Virtual Enterprise Environments	Upgraded, Integrated Infrastructure Networks	Niche Industries
Additive Manufacturing	Smart Logistic Tools	Social Manufacturing
	Sustainable Manufacturing	
	Agile Manufacturing	
	Eco-Industry Services	
	Developing Talents	
	Complex Value Chain	
	Open Innovation	
	Intel and Intermodal Transport Infrastructure	
	Circulation of Materials and Parts	
	Waste Minimisation	
	Personalised Product Lines	

Table 2. Circular Economy Factors grouped per category

The first conclusion is clear: challenge is in the processes!

However, the evolution of technologies alone is not enough to produce an impact that makes the sector grow. At every level, new technologies need to be integrated into traditional business processes (production, quality control, research and development, marketing, human resources) for a harmonious growth of the company along its entire value chain.

In this respect, the DITRAMA[8] project has always identified, through a survey among sector operator, the technologies that will have the greatest impact on the wood-furniture sector, perfecting the results that emerged from DIGIT-FUR and confirming integration among the top technological systems.

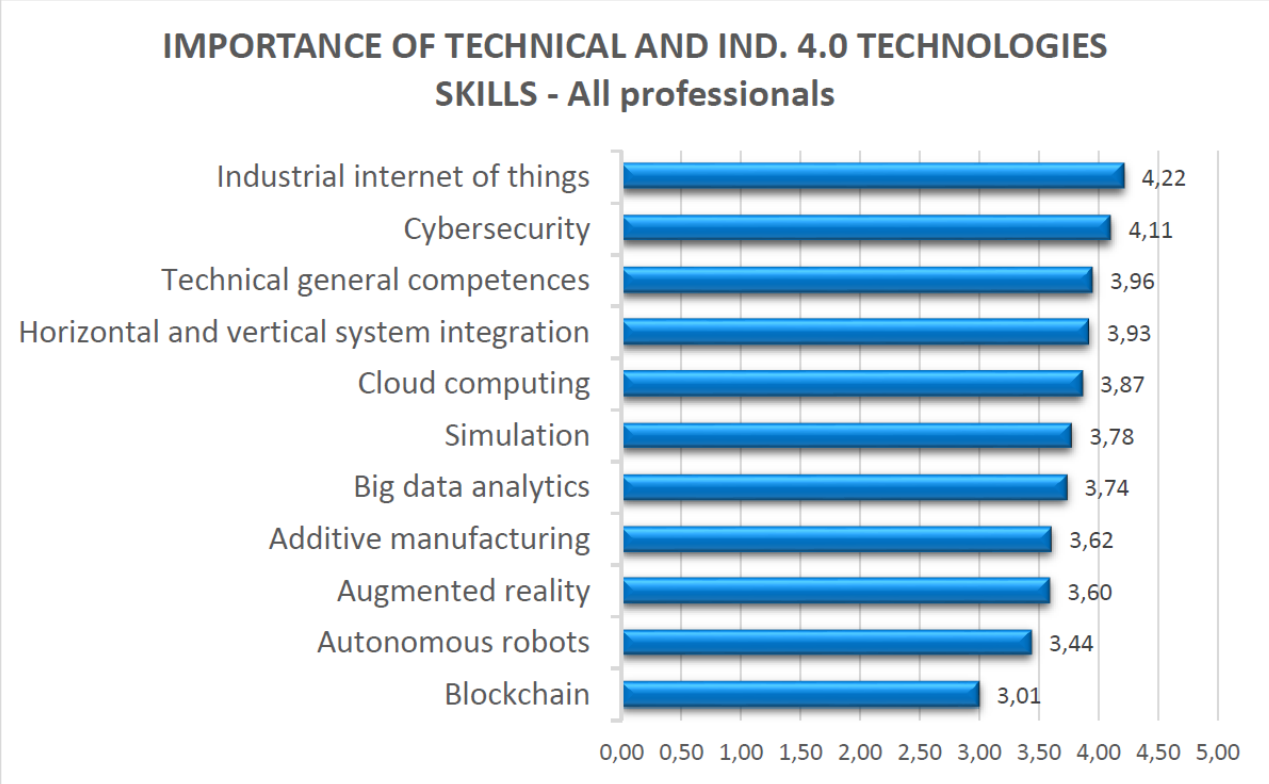

Figure 2. Ranking of the Top important technologies for the wood-furniture sector according DITRAMA survey

From these elements, business digital transition seems to evolve along four main lines:

1) Integration of technologies into traditional products and their evolution into "intelligent and interconnected products" (Internet of Things)
2) Introduction into business processes of innovative technologies for design (Augmented Reality, Virtual Reality, Mixed Reality, Digital TWIN, Simulation), production (additive manufacturing / rapid prototyping / autonomous robots), protection of intellectual property (Blockchain).
3) New working methods, which use technology to improve its effectiveness, even remotely (cloud technologies, agile and sustainable manufacturing).

[8] DITRAMA – Erasmus+ - 601011-EPP-1-2018-1-ES-EPPKA2-SSA –– See output D2.4° "Skills Fine Tune – Final Report" – Page 21. www.ditrama.eu

4) New technologies for relations with both the market and customers (from big data / data visualization to analyze the market to virtual reality for the remote presentation of solutions and products to the customer, passing through social manufacturing for the customer involvement in co-creation.

2.2 Green Transition. SAWYER – Impacts of the twin transition on the EU furniture industry

The SAWYER Project interviewed 51 experts from 15 European countries, submitting them a list of 49 possible evolutions and impact on the sector of numerous environment-related legislative and voluntary tools. Experts confirmed the following trends for the sector:

- Growth in the offer of products designed according to the principles of eco-design (low environmental impact, traceability of the origin of raw materials, sustainable production processes).
- Development of methodologies for the recovery and reuse of post-consumer materials.
- Market increasingly looking for information about the sustainability of products and products with environmental certifications, also for the construction sector (LEED / BREEAM certifications).
- Development of policies and regulations to reduce waste production and end-of-life management of products.
- Development of public and private schemes of Green Public Procurement.
- Cascade use of wood (use of wood in several stages, as raw material or building material. Wood will be used for energy production only when unsuitable for any type of use. This way, the carbon reserve offered by the wood and preserved by wooden products remains available for as long as possible, with significant economic advantages, since the value of the material increases in each processing stage.
- Development of extended producer responsibility, in which the producer has the financial and organizational responsibility of managing the final phase of a product's life cycle, i.e. when it becomes waste, including separate collection, sorting and treatment operations.
- Development of the REACH regulation, adopted by the European Community to improve the protection of human health and the environment from the risks that may arise from chemicals. The REACH regulation places the burden of proof on companies. So companies, according to the regulation, must identify and manage the risks associated with the substances they produce and market in the European Union. They must demonstrate to ECHA how they use these

substances without running risks and communicate the risk management measures to users.

All these scenarios require the development of Green skills, which can be divided into "Soft Generic Green Skills" and "Technical Green Skills":

Soft Generic Green Skills

- environmental awareness and willingness to learn: about sustainable development;
- systems and risk analysis skills to assess, interpret and understand both the need for change and the specific measures required;
- innovation skills to identify opportunities and create new strategies to respond to green challenges;
- coordination, management and business skills to facilitate holistic and interdisciplinary approaches incorporating economic, social and ecological objectives;
- communication and negotiation skills to discuss conflicting interests in complex contexts;
- marketing skills to promote greener products and services;
- strategic and leadership skills to enable policy-makers and business executives to set the right incentives and create conditions conducive to cleaner production, cleaner transport etc...;
- consulting skills to advise consumers about green solutions and to spread the use of green technologies;
- networking, information technology and language skills to enable performance in global markets;
- adaptability and transferability skills to enable workers to learn and apply the new technologies and processes required to green their jobs;
- entrepreneurial skills to seize the opportunities relating to low-carbon technologies;
- waste, energy and water quantification and monitoring;
- material use and impact quantification and monitoring in procurement and selection
- material use and impact minimization (impact assessment)

Technical Green Skill

- life cycle assessment: materials selection, materials re-use, appropriate disposal;
- impact minimization and reporting for sustainability;
- green procurement and souring of local wood;
- energy conservation and energy efficient production;
- waste reduction/management;
- stakeholder engagement.

According to the ReSOLVE (ReSOLVE Framework) developed by McKinsey in co-operation with Ellen McArthur Foundation and adapted to the sector, the wood-furniture sector can complete its transition towards circular economy by focusing in 6 different areas:

- Regenerate: ex. shift to renewable energies / materials - Reclaim, retain, and regenerate health of ecosystems - Return recovered biological resources to the biosphere
- Share: Reduce product replacement speed and increase product utilisation by sharing it among different users - Reuse products throughout their technical lifetime - Prolong products lifetime through maintenance/repair/design for durability
- Optimise: Increase performance/efficiency of products and production processes - Customisation/made to order - Reproductible and adaptable manufacturing - Minimize waste in production and supply chain
- Loop: Remanufacturing products and/or components - Implement takeback programs - Recycling materials - Promote the cascade use of wood - Promote extraction of biochemicals from organic waste
- Virtualise: Virtualise direct / indirect aspects of the product
- Exchange: Replace old materials with advanced renewable ones - Apply new technologies - Choose new products and services.

Digitization and the new technologies available also impact on aspects relating to environmental sustainability through traceability tools for materials, products and components, as well as traceability technologies (QR Code / RFID). This information can be integrated with booming e-commerce portals to provide the final consumer with detailed information.

3. The impact of "Twin Transition" on traditional wood-furniture professions. The professional profile of Woodworker 4.0

The double transition has an impact on traditional wood-furniture professions, in a context of continuous evolution.

The recent BOLSTER-UP II project, financed under the Social Dialogue[9] program, has analyzed all the Skills, Competences and Knowledge required for three professions characterizing the sector (Joiner, Cabinet-Maker, Upholsterer), indicating their evolution from the previous survey in 2014.

For each of the three profiles, the evolution involves the acquisition of new skills such as:

Digital Skills:

- using data systems (digital skills)
- working with automated machines (CNC machines and computerised equipment)
- using (C)NC-programming
- knowing digital simulation models, working in an environment with advanced digital process control, cobots and robots
- use the company's ICT system and standard software related to their work field
- understanding of work-flow and sequence of operations

Green Skills:

- acting responsibly, also complying with security regulations, health and environmental protection
- contributing to maintenance activities and waste management
- using energy efficiently

[9] BOLSTER UP II Project – Social Dialogue EU Programme – *Report on European furniture professions*. www.bolster-up2.eu

These general recommendations are analyzed in detail by the SAWYER and DIGIT-FUR projects, which redefine 11 professional profiles (identified according to the ESCO classification for the sector) based on the identified scenarios.

We analyze in particular the professions consistent with the purposes of WOODIGITAL, focusing in particular on:

1) Cabinet Maker and related workers
2) Upholsterer and related workers
3) Furniture Assembler

3.1 Cabinet Maker and related workers

Profile evolution due to the Twin Transition[10]

Cabinet-makers and related workers make, decorate and repair wooden furniture, carts and other vehicles, wheels, parts, fittings, patterns, models and other wooden products using ***highly digitized, connected and automated woodworking machines*** *and machine tools as well as specialized hand tools.*

- Works in accordance with basic health and safety regulations, including environmental protection and efficient energy use
- Use digitization tools to work in a customer-oriented manner
- Considers cost, environmental impact and time-effectiveness when planning and organizing his/her work in his/her area of influence
- Contributes to continuous improvement of work processes in the company
- Coordinates work with the rest of the team, report to his/her team leader
- Cooperates with other departments (administrative, commercial, ICT and technical services)
- Assists in the implementation of quality assurance and sustainability activities
- Assists in the reduction of the environmental impact of the manufacturing, repair, remanufacturing or recycling processes (e.g. waste generation or energy use reduction, etc.)
- Applies a life-cycle thinking approach and favour the future disassembly of the product for maintenance, repair, reuse or recycling.

[10] *DIGIT-FUR: Impacts of the digital transformation in the wood furniture industry*– page 63. www.digit-fur.eu *SAWYER: Impacts of the twin transition on the EU furniture industry*– page 63. www.circularfurniture-sawyer.eu

In the following table the new skills forecasted for the Cabinet Maker and related Workers Profile are listed[11]:

		Will it continue to be needed?	Main reasons of change				
			Use digitization tools to work in a customer-oriented manner	Using highly digitized, connected and automated (autonomous) woodworking machines	Simulation and use of digital twins to study and optimize	Human-robot collaboration, use of cobots, that can be remotely operated (with the help of Augmented Reality) using big data	Create designs, using digital simulation tools like digital twins and augmented reality
Essential skills and competences	Apply a protective layer	YES, changed		•		•	
	Apply wood finishes	YES, changed		•		•	
	Clean wood surface	YES, changed		•		•	
	Create furniture frames	YES, changed		•		•	
	Create smooth wood surface	YES, changed		•		•	
	Design objects to be crafted	YES, changed			•		•
	Design original furniture	YES, changed			•		•
	Join wood elements	YES, changed		•		•	
	Operate drilling equipment	YES, changed		•		•	
	Operate wood sawing equipment	YES, changed		•		•	
	Repair furniture frames	YES, changed		•		•	
	Sand wood	YES, changed		•		•	
	Tend boring machine	YES, changed		•		•	
Essential knowledge	Construction products	YES, changed	•		•		•
	Furniture trends	YES, changed	•		•		
	Sanding techniques	YES, changed		•		•	
	Technical drawings	YES, changed	•		•		•
	Types of wood	YES					
	Wood products	YES					
	Woodturning	YES, changed		•		•	
NEW skills, knowledge and competences	Critical Thinking and Problem Solving	NEW	•	•	•	•	
	Collaboration Across Networks and Leading by Influence	NEW	•		•	•	•
	Agility and Adaptability	NEW	•	•	•	•	•
	Initiative and Entrepreneurship	NEW		•	•		•
	Effective Oral - Written Communication	NEW					•
	Assessing and Analyzing Information	NEW	•	•	•	•	•
	Curiosity and Imagination	NEW			•		•
	Digital literacy	NEW	•	•	•	•	•
	Data security	NEW	•		•		•

Figure 3. Cabinet Maker evolution profile according to the DIGIT-FUR forecasting

[11] *DIGIT-FUR: Impacts of the digital transformation in the wood furniture industry* – page 68. www.digit-fur.eu

3.2 Upholsterer and related workers

Profile evolution due to the Twin Transition[12]

Upholsterers and related workers install, repair and replace upholstery of furniture, fixtures, seats, panels, convertible and vinyl tops and other furnishings of automobiles, railway coaches, aircraft, ships and similar items with fabric, leather, rexine or other upholstery material ***using ecoefficient semi-automatic or fully automated*** *machines. They also make and repair cushions, quilts and mattresses.*

- Works in accordance with basic health and safety regulations, including environmental protection and efficient energy use
- Uses digitization tools to work in a customer-oriented manner
- Considers cost, environmental impact and time-effectiveness when planning and organizing his/her work in his/her area of influence
- Contributes to continuous improvement of work processes in the company
- Coordinates work with the rest of the team, report to his/her team leader
- Cooperates with other departments (administrative, commercial, ICT- and technical services)
- Assists in the implementation of quality assurance and sustainability activities
- Assists in the reduction of the environmental impact of the manufacturing, repair, remanufacturing or recycling processes (e.g. materials used, waste generation or energy use reduction, etc.).
- Uses a life-cycle thinking approach when takes decisions on the materials to be used and favours the future disassembly of the product for maintenance, repair, reuse or recycling.

In the following table the new skills forecasted for the Upholsterer and Related Workers Profile are listed[13]:

[12] *DIGIT-FUR: Impacts of the digital transformation in the wood furniture industry* – page 79. www.digit-fur.eu *SAWYER: Impacts of the twin transition on the EU furniture industry* – page 87. www.circularfurniture-sawyer.eu

[13] *DIGIT-FUR: Impacts of the digital transformation in the wood furniture industry* – page 84. www.digit-fur.eu

		Will it continue to be needed?	Main reasons of change			
			Using semi-automatic or fully automated operating machines and connected cobots	Use digitization tools to work in a customer-oriented manner	Using digital simulation models, computer vision and digital twin simulation models	Using advanced digital process control
Essential skills and competences	Clean furniture	YES				
	Create patterns for textile products	YES, changed		•	•	•
	Cut textiles	YES, changed	•	•	•	•
	Decorate furniture	YES				
	Fasten components	YES, changed	•		•	
	Install spring suspension	YES, changed	•			
	Perform upholstery repair	YES, changed	•			
	Provide customized upholstery	YES, changed	•	•	•	
	Sew pieces of fabric	YES, changed	•		•	•
	Sew textile-based articles	YES, changed	•	•	•	•
	Use manual sewing techniques	NO				
Essential knowledge	Furniture industry	YES				
	Furniture trends	YES				
	Textile materials	YES, changed	•		•	
	Upholstery fillings	YES, changed	•		•	
	Upholstery tools	YES, changed	•			
NEW skills, knowledge and competences	Critical Thinking and Problem Solving	NEW	•	•		•
	Collaboration Across Networks and Leading by Influence	NEW		•	•	
	Agility and Adaptability	NEW	•	•	•	•
	Initiative and Entrepreneurship	NEW	•		•	
	Effective Oral - Written Communication	NEW			•	
	Assessing and Analyzing Information	NEW	•	•	•	•
	Curiosity and Imagination	NEW			•	
	Digital literacy	NEW	•	•	•	•
	Data security	NEW		•	•	•

Figure 4. Upholsterer evolution profile according to the DIGIT-FUR forecasting

3.3 Furniture Assembler

Profile evolution due to the Twin Transition[14]

[14] *DIGIT-FUR: Impacts of the digital transformation in the wood furniture industry*– page 95. www.digit-fur.eu *SAWYER: Impacts of the twin transition on the EU furniture industry*– page 105. www.circularfurniture-sawyer.eu

Furniture assemblers place together all parts of furniture and auxiliary items such as furniture legs and cushions. They may also fit springs or special mechanisms. Furniture assembling is done by ***joint cooperation between robots and humans using cobots*** *and sometimes it is* ***significantly automated*** *eventually into a* ***fully autonomous process using cobots, big data and industrial IoT****.*

- Works in accordance with basic health and safety regulations, including environmental protection and efficient energy use
- Use digitization tools to work in a customer-oriented manner
- Considers cost, environmental impact and time-effectiveness when planning and organizing his/her work in his/her area of influence
- Contributes to continuous improvement of work processes in the company
- Coordinates work with the rest of the team, report to his/her team leader
- cooperates with other departments (administrative, commercial, ICT- and technical services)
- Assists in the implementation of quality assurance and sustainability activities
- Assists in the reduction of the environmental impact of the manufacturing, repair, remanufacturing or recycling processes (e.g. waste generation or energy use reduction, etc.).
- Applies a life-cycle thinking and favours the future disassembly of the product for maintenance, repair, reuse or recycling.

In the following table the new skills forecasted for the Furniture Assembler are listed[15]:

[15] *DIGIT-FUR: Impacts of the digital transformation in the wood furniture industry* – page 100. www.digit-fur.eu

		Will it continue to be needed?	Main reasons of change		
			Furniture assembling is done by joint cooperation between robots and humans using cobots, big data and industrial IoT	Working in a highly digitized smart manufacturing ecosystem, with digitilized forms	Working as an integrated part of the fully digitized ecosystem of the company
Essential skills and competences	Align components	YES, changed	•		
	Apply a protective layer	YES			
	Assemble prefabricated furniture	YES, changed	•		
	Clean wood surface	YES			
	Create furniture frames	YES			
	Create smooth wood surface	YES			
	Ensure conformity to specifications	YES, changed		•	
	Follow written instructions	YES, changed	•	•	
	Join wood elements	YES, changed	•		
	Memorise assembly instructions	NO			
	Operate drilling equipment	YES, changed	•		
	Tend boring machine	YES, changed	•		
	Use power tools	YES, changed	•		
Essencial knowledge	Technical drawings	YES, changed		•	
NEW skills, knowledge and competences	Critical Thinking and Problem Solving	NEW	•	•	•
	Collaboration Across Networks and Leading by Influence	NEW	•		
	Agility and Adaptability	NEW	•	•	•
	Initiative and Entrepreneurship				
	Effective Oral and Written Communication	NEW		•	
	Assessing and Analyzing Information	NEW		•	
	Curiosity and Imagination	NEW	•	•	•
	Digital literacy	NEW	•	•	•
	Data security	NEW		•	•

Figure 5. Furniture Assembler evolution profile according to the DIGIT-FUR forecasting

In addition to core skills, specific for each profile, "Twin Transition" requires the acquisition of a set of new Skills / Knowledge / Competences consistent with the scenarios outlined, summarized in the following tables. To the professional profile of the Cabinet maker, we also combine that of the Carpenter and Joiner for the homogeneity of skills required.

ESCO PROFILE	DIGITAL SKILLS	GREEN SKILLS
Cabinet Maker and related workers / Carpenter and Joiner	*Knowledge of automated machines (CNC machines – Laser Cutter)*	*Fundamentals of environmental regulation*
	Knowledge of 3D Printing	*Fundamentals of efficient energy use*
	Knowledge of CAD / CAM / BIM	*Fundamentals of waste management*
	Fundamentals of IoT	*Fundamentals of Eco-design*
	Fundamentals of VR / AR	*Knowledge of new and eco-materials*
	Fundamentals of Digital Twins simulation Models	*Fundamentals of Circular Economy Models*
	Fundamentals of Cloud Technologies	
	Fundamentals of Industry 4.0	

Table 2. Digital and Green Skills for the profile of the Cabinet Maker and related workers (including carpenter and joiner)

ESCO PROFILE	DIGITAL SKILLS	GREEN SKILLS
Upholsterer and related workers	*Knowledge of automated machines (CNC machines - Laser Cutter)*	*Fundamentals of environmental regulation*
	Knowledge of 3D Printing	*Fundamentals of efficient energy use*
	Knowledge of CAD / CAM	*Fundamentals of waste management*
	Fundamentals of VR / AR	*Knowledge of Eco-design*
	Fundamentals of IoT	*Knowledge of new and eco-materials*
	Fundamentals of Digital Twins simulation Models	*Fundamentals of Circular Economy Models*
	Fundamentals of Cloud Technologies	
	Fundamentals of Industry 4.0	

Table 3. Digital and Green Skills for the profile of the Upholsterer and related workers

ESCO PROFILE	DIGITAL SKILLS	GREEN SKILLS
Furniture Assembler	*Knowledge of Robots / Cobots*	*Fundamentals of environmental regulation*
	Knowledge of 3D Printing	*Fundamentals of efficient energy use*
	Knowledge of CAD / CAM	*Fundamentals of waste management*
	Knowledge of IoT	*Fundamentals of Eco-design*
	Knowledge of AR / VR solutions	*Knowledge of new and eco-materials*
	Knowledge of Additive manufacturing	*Fundamentals of Circular Economy Models*
	Fundamentals of Remote Monitoring and Control	
	Fundamentals of Digital Twins simulation Models	
	Fundamentals of Big Data analysis	
	Fundamentals of system integration	
	Fundamentals of Cloud Technologies	
	Fundamentals of Industry 4.0	

Table 4. Digital and Green Skills for the profile of Furniture Assembler

Added to this are other transversal, non-technical skills, which complete the profile of the "Woodworker 4.0":

- Trendwatching / Knowledge of New Lifestyles
  Even more important than the content is the ability to deal with the social changes that impact the world of work. It is essential to know that the economic and social scenario changes, evolves and it is possible to identify the signs of this change.

- Risk Management and new hazards, for instance Psychosocial hazards due to lack of social contacts and mental stress due to cognitive interaction with cobots/machines/robots
  Attention to safety at work is a shared responsibility between the worker and the company. The worker is asked to know the risks associated with his activity, the use of tools and methods to mitigate them.

- Ethics
  Respect for people, the resources available, the environment are essential factors for the formation of "Woodworker 4.0", with particular attention also to aspects of digital ethics, netiquette, inclusion.

- Intercultural Skills

Furniture companies operate in a global context: they interact with operators (buyers, retailers, creatives, designers, dealers) from different cultures, they welcome workers and employees from other cultures and countries. Team building skills, intercultural collaboration, respect for different habits and customs, including language skills in at least one foreign language, are essential for a Woodworker 4.0.

- Communication Skills
  Effective oral and Written communication and basic knowledge of the specific furniture jargon.

- Entrepreneurial Skills
  Agility and adaptability, ability to take the initiative, curiosity and imagination are essential for a Woodworker 4.0.

4. Conclusion: new professional profiles, new skills, new teaching methodologies

In 2015, the FUNES[16] project had already identified 3 out of 7 factors linked to the lack of training among the main weaknesses of the European furniture sector:

- Management training needs
- Low education of workers
- Lack of competences to work with new and different materials (polymers, glasses, stones, composite,...)

Digital challenges were still in evolution but represented a clear development opportunity. In DITRAMA[17], the lack of adequate staff skills and training, combined with a lack of leadership and resistance to change is indicated among the major barriers to the implementation of technological development in companies.

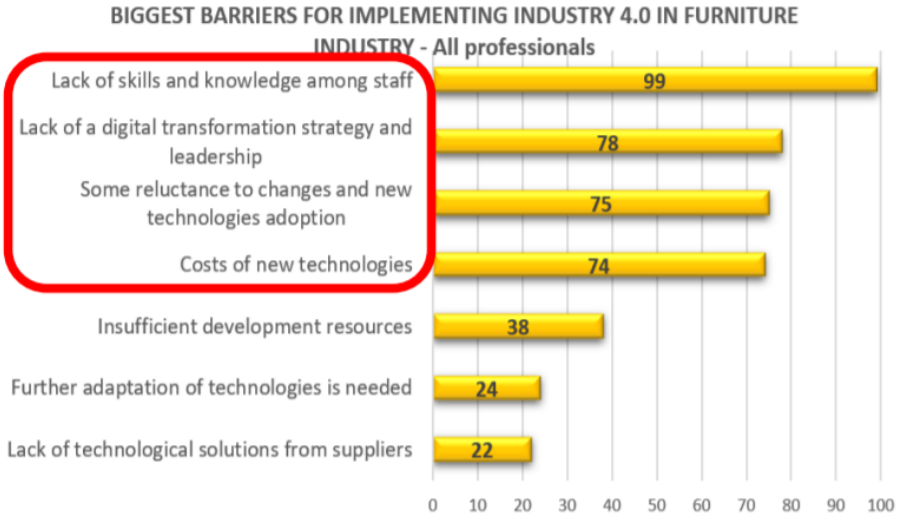

Figure 6. Biggest Barriers for implementing industry 4.0 in Furniture industry according DITRAMA survey

[16] FUNES Project – Erasmus + EU Programme - Output O3 – A1 – *Analysis of Companies versus Scenario* – Page 5. www.funesproject.eu

[17] DITRAMA Project- Erasmus + EU Programme - Output D2.4 "*Skills Fine Tune – Final Report*" – Page 23. www.ditrama.eu

The lack of skills adequate to the change in progress requires a training effort that reviews not only the contents, but also the methods of delivery of the training contents.

The weakness of knowledge of new technologies[18]

It is Bolster UP II that provides some indications to remedy these sectoral weaknesses, through new training methodologies, in which learning what is new is combined with new teaching methods.

The following training content and tools are strongly recommended:

- Digital support for using machines (use of Augmented Reality)
- Digital support for mounting (use of Augmented Reality)
- Education on principles of circular economy
- Training in environmental procedures
- Training in waste management
- Training in regulations and procedures in OHS (occupational health and safety)
- Surveillance of new materials (antenna)
- Looking out for and assessing new applications (antenna)

[18] IN4WOOD Project – Erasmus+ EU Programme - www.in4wood.eu

Tables and figures

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Figures

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